

RF Performance Predictions for Real Time Shipboard Applications

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LONG TERM GOALS

Develop electromagnetic propagation models, that perform equally well over land and sea and in the presence of anomalous propagation conditions for both surface and airborne emitters, for use in operational or engineering propagation assessment systems.

OBJECTIVES

The specific technical objectives are to 1) develop a method to extract rainfall data from the tactical scans of the SPS-48 radar and provide the rain data in a form suitable for propagation models such as the Earth-to-Satellite Propagation Model with METOC (ESPM2) and the Advanced Propagation

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Model (APM); and 2) modify the current statistics-based rain attenuation model within the ESPM2 and the APM to ingest real time rainfall rate data obtained from shipboard radar (SPS-48 initially).

APPROACH

The problem of obtaining accurate rain rates from radar returns is an old one and has been studied by the weather radar community for many years. In the usual application, the problem is the prediction of rain rates at the ground from measurements made aloft by the radar. In our case, the rain rate is an intermediate parameter used to specify the attenuation rate for RF propagation. So our approach has been to use the results from the work that has been done as it applies to our particular application but some modifications are required. We also retain parts of the ITU rain attenuation model as they apply to the current effort.

A common problem one faces in developing shipboard applications is that of obtaining verification and validation data in open ocean areas. Specifically, the relationship between reflectivity factor (Z) and rain rate (R) is highly dependent on geographic location and rain type [1]. While many attempts have been made to develop a general relationship that is suitably accurate in all situations, it remains true that this relationship is highly variable. The lack of open ocean data and the mobility of the shipboard radar make it even more difficult to obtain a single parametric relationship that is accurate in all situations. However, before these difficult questions can be researched, an estimate of the accuracy of the model as it exists needs to be obtained. So our plans for this year included the collection of data suitable for an end-to-end assessment of the accuracy of the model that was developed earlier under this effort. An end-to-end assessment requires basic refractivity data from a SPS-48 shipboard weapons radar from which our conversion to rain rates can be verified. From the rain rates we obtain rain attenuation estimates which can only be verified by comparison to measured attenuation rates during the same rain events. The availability of the SPS-48 radar at Dam Neck, VA gives us an opportunity to collect the required data set at a fixed, land based site.

RESULTS

The rain attenuation model developed in previous years has been described in previous reports and mid-year reviews and will not be repeated here [2,3]. The effort this year was to be centered on the collection of data suitable for assessing the accuracy of the model for a 'simple' application of a fixed radar site. The data set must be capable of assessing the complete model, from estimating rain rates from radar data to estimating attenuation on RF propagation paths.

We began this effort by running simulations for the Dam Neck, VA area to assess propagation conditions for the area and to select frequencies for the measurements. We then approached personnel at the Dam Neck, VA radar site and Naval Air Station (NAS) Oceana and obtained permission to use their facilities for the establishment of the RF propagation path from Dam Neck to NAS Oceana, a path of approximately 4.5 kilometers. A diagram of the basic system design is shown in Figure 1, where the transmitter is at Dam Neck, co-located with the SPS-48 radar, and the receiver site is at NAS Oceana. Because of the circumstances described below, the delay in performing the measurements has allowed us to borrow almost all of the equipment (excluding the rain gauge and cabling) shown in Fig. 1, thus reducing the equipment costs of this effort by a significant amount.

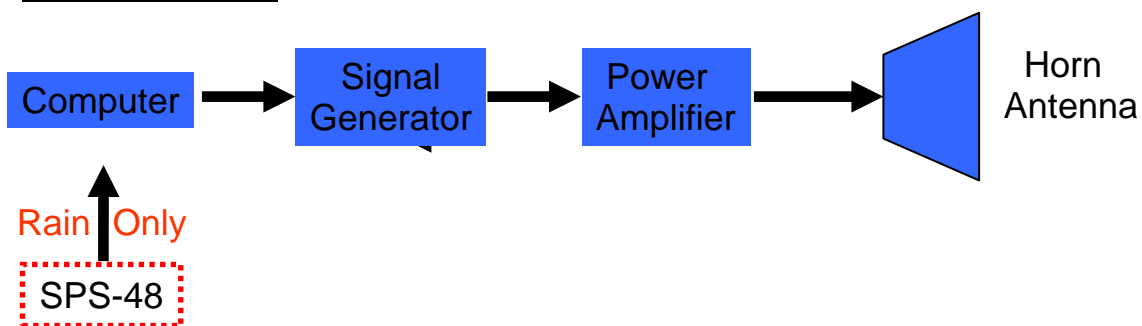
The operation schedule calls for transmitting each of three frequencies sequentially for 20 seconds each as the basic transmission block (BTB). During dry periods the BTB will be repeated every five

minutes and the data stored to an external drive. During rain events the BTB will be repeated as often as every minute, while simultaneously collecting rain amount data from the rain gauge, prevailing wind data and UF files from the SPS-48 radar on a similar schedule. The data collected during non-rain periods will be averaged to give background estimates of received signal strength for comparison to data taken during rain events.

Software for controlling the system is largely complete, requiring only the integration of the rain gauge and wind gauge and the external storage device on the receive end.

The data collection campaign was scheduled to be executed during the July/August time frame of 2010. These are the peak rain fall months for the NAS Oceana area. However, extreme delays in obtaining Department of Defense (DoD) certification for operating in the Virginia area, coupled with the scheduled October 2010 upgrade of the Dam Neck SPS-48E to the SPS-48G, forced us to delay performing the measurements in 2010. The revised plan is to perform the measurements in July/August 2011, when the radar upgrade is completed. The measurement system will be largely completed and certification obtained by early 2011 so we will be prepared to begin measurements as originally planned.

TRANSMITTER:



RECEIVER:

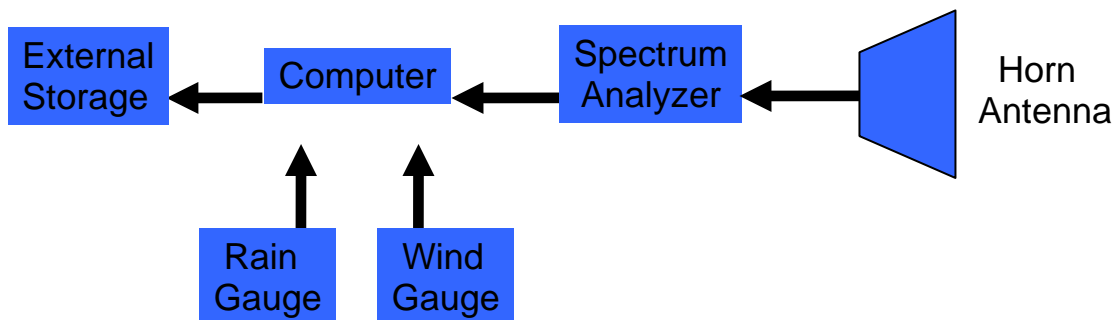


Figure 1. Diagram of the planned measurement system to be used during the field campaign.

IMPACT/APPLICATIONS

The primary payoff of this task is to allow a shipboard user of the ESPM2 and the APM to use real time weather data, which will become available in the near future, to provide more accurate assessment of expected system performance and allow tuning of system parameters (i.e. transmitter power levels) to meet performance criteria while, perhaps, conserving shipboard assets.

TRANSITIONS

Propagation models and applications developed under this task and intended for operational use transition into the Naval Integrated Tactical Environmental Subsystem (NITES) EM module, PE 0603207N, and could also transition into any other propagation assessment system. Models will transition into the Oceanographic and Atmospheric Master Library (OAML), from which they will be available for transition or incorporation into any assessment, simulation, or engineering-support system that needs them. Propagation models and algorithms under this task and intended for operational use may also transition to the Littoral Battlespace Sensing, Fusion, and Integration (LBSF&I) program (PE 0603207N). The propagation models and algorithms developed under this task will significantly aid in the overarching capability under the LBSF&I program to provide a completely integrated end-to-end “system of systems”.

RELATED PROJECTS

Efforts under this task are related to the Joint Tactical Radio System (JTRS) program and any related program requiring SATCOM performance assessment. Under the tri-service Battlespace Environments Technology Area Plan, our propagation models are also available to both Air Force and Army.

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3. Sprague, R. A., P. Babu, N. Fuhrer, “RF Rain Attenuation from Shipboard Radar Clutter”, *Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO)* Conference, Omaha, NE, April 2010.

PUBLICATIONS

1. Sprague, R. A., P. Babu, N. Fuhrer, “RF Rain Attenuation from Shipboard Radar Clutter”, *Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO)* Conference, Omaha, NE, April 2010.